

Part

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Landscape Assessment of Geomorphic Sensitivity

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Purpose

To estimate the natural geomorphic sensitivity of the landscape and watershed sensitivity to land use disturbances. Geomorphic sensitivity analysis provides a measure of the terrain's resilience and susceptibility to change. In contrast, biologic sensitivity describes the resilience of the biological system to change.

Background

A basic premise behind this assessment is that landscapes differ in their natural susceptibility to erosion and mass soil movement processes, and therefore in their geomorphic sensitivity to forest practice activities. Both hydrologic and geomorphic processes vary spatially with differences in climate, geology, soils, vegetation, fire histories and terrain characteristics. Ultimately, in the natural setting, vegetation and habitat conditions, and the fauna which rely on them, are controlled by these processes. Subsequently, human-caused disturbance events (land use) in the watershed has added additional variability to the natural setting.

Because of the diversity of natural conditions, all areas in a watershed and within an ownership are not equally sensitive to any particular forest practice activity. Consequently, the risks to water quality and aquatic habitat, associated with a range of natural conditions and management activities, can be expected to vary from place to place. The task is to provide some measure or sense of this spatial variability, using existing information, which will help land managers plan for future, area-wide activities.

The challenge is to develop a conceptual model of watershed sensitivity that is based on physical factors that are relevant to slope instability and erosion, and then to depict the distribution of these factors in a manner that is both logical and locally meaningful. Limitations in the state-of-the-art, as well as data limitations for most wildland watersheds, precludes development of a quantitative, process-based model to predict absolute watershed sensitivity. For this reason, field inspections and project level assessments will continue to play a critical part in evaluating a watershed's geomorphic sensitivity and predicting the effects of proposed land use activities.

Watersheds display a non-homogenous temporal and spatial response to disturbance. Watershed effects may not occur for a number of years following land management, and then only in response to a triggering climatic event. In other cases, impacts to the fluvial system may occur in a progressive manner as a result of annual events and inputs. Similarly, although on-site erosion may accompany land use activities, increased erosion may also occur downslope and downstream from the site of the disturbance.

Ecological and geomorphic systems are complex and vary from one watershed to another. For this reason, a precise, technical model of watershed sensitivity cannot yet be

formulated. No one model will simulate all the contributing variables, nor does our current level of understanding allow us to identify and quantitatively rate each possible variable. We can only hope to select relevant and relatively meaningful variables to describe the overall watershed condition. Some of the variables affecting processes and process rates include geology/soils, geomorphology/terrain, climate, vegetation and human activities.

Approach

The risk identification process described here is an area-wide assessment of relative watershed risk or geomorphic sensitivity using existing spatial or map data relevant to slope hazard assessment and sediment source identification (Bernath, et. al., 1992). The presumption is that physical characteristics of the watershed can be correlated to landslide potential, soil erosion potential and stream bank erosion potential, as described by CDMG (1985). The layers of data and information available for watersheds in the ownership now provide enough technical information to evaluate natural watershed sensitivity on a landscape scale, and to compare overall conditions from watershed to watershed.

For example, the published CDMG watershed maps, available for most of the Company's property, allow users to recognize and flag areas of potentially unstable ground and to foresee and minimize potential problems in these areas (CDMG, 1985). The maps were specifically designed to identify unstable and erosion-prone areas on a regional scale, and to assist in the preparation of large-scale, long range management plans (such as a S.Y.P.) that use geologic information to minimize environmental impacts. Through combination with other available data, they can be employed to ultimately reduce erosion and landsliding, and enhance water quality (CDMG, 1985).

In addition to the CDMG geomorphic maps, GIS information (layers) for the ownership also include digital elevation data (used to derive slope maps), soils information, bedrock mapping, vegetation, harvest history data, roads and streams. Risk or sensitivity mapping will incorporate this available digital map information and result in the production of synthesized data layers that depict the location and distribution of naturally sensitive, steep and potentially unstable areas.

In developing a landscape sensitivity rating, the following GIS data layers were used:

1. A steep area layer showing:

- Slopes >35% to 50% - moderate
- Slopes >50% to 65% - steep
- Slopes >50% to 65% - extending to a stream channel - steep inner gorge
- Slopes >65% - very steep
- Slopes >65% - extending to a stream channel - very steep inner gorge

2. An unstable area layer showing:

- CDMG geomorphic maps, including data layer categories:
 - Bedrock geology

- Landslide terrain (active landslides, disrupted ground, debris slides and debris slide slopes, translational/rotational landslides and earthflows)
- Unstable and erodible soils (e.g., Atwell)

This methodology allows for the delineation of steep terrain as well as potentially unstable and extremely unstable lands including active landslides, valley inner gorges, shear zones and dormant landslide areas, steep and very steep slopes, and other areas known by experience and observation to be unstable (Bernath, 1992). Smaller features on the landscape will be missed by this process, due to the scale limitations of digital map data and maps derived from large scale aerial photographic interpretation. However, these isolated areas will be picked up during future field inspections and hillslope assessments.

A risk or sensitivity map was then prepared, with accompanying data tables, defining the steep and unstable areas of each watershed. Attached to the end of this section are tables containing factor values for data layers of soils, bedrock geology, geomorphology and slope gradients. These individual resource ratings were then accumulated and grouped as the following preliminary sensitivity ratings: very low (1-5), low (6-10), moderate (11-15), high (16-20), very high (21-25) and extreme (>25). Integrated resource sensitivity maps were then produced for the ownership.

Discussion of Uses and Limitations

The procedure employed here uses known, existing information to make a preliminary assessment of the natural susceptibility of a watershed area. It is not intended to supplant field inspections and site analyses, but can aid in defining or predicting which project-level areas may need more detailed investigation and evaluation.

The basic assessment methodology is used to identify and describe important geomorphic attributes of a watershed and to develop an understanding of the watershed system and factors which may influence watershed response to land use. Watershed boundaries form the basic area of analysis. The assessment largely applies to existing conditions, and an assessment of the effects of future activities. However, the importance of watershed history in evaluating the current condition of a watershed and its stream system cannot be overlooked, and needs to be factored into the assessment. History includes both significant natural events as well as human land use (nature, timing, extent and recovery time). The response of a watershed to past storms and land use reveals the integration of these effects. Watershed history documents effects that can last for a decade, or longer.

Natural watershed sensitivity is an estimation of a watershed's natural ability to absorb land use disturbance without unacceptably high level of impact (USDA, 1988). For the aquatic system, it means the ability of a watershed to accommodate land management without significant or lasting impacts to the aquatic ecosystem. The measure of susceptibility may be a geomorphic or a biologic response in the stream system, or it may be some more restrictive management limit that is imposed before such a response occurs.

In general, natural watershed sensitivity to land use increases as the percentage of geomorphically sensitive lands and stream channels in the watershed increases (USDA, 1988). Not all land units contribute equally to natural sensitivity. Likewise, the location of sensitive lands, especially relative to stream channels, also influences watershed sensitivity. Depending on their natural geomorphic sensitivity, watersheds have varying tolerances to

land use activities. The more sensitive watersheds are less tolerant and will require greater care in planning and conducting land use.

References

- CDMG, 1985, *CDF/DMG watershed mapping*, California Division of Mines and Geology, Sacramento, California, (68 maps available).
- Bernath, S., M. Brunengo, S. Smith and L. Lackey, 1992, *Using GIS and image processing to prioritize cumulative effects assessment*, GIS '92 Symposium, Vancouver, British Columbia, February, 1992, 6 pages.
- USDA Forest Service, 1988, *Cumulative off-site watershed effects analysis*, In: Soil and Water Conservation Handbook (chapter 20), Region 5, Pacific Southwest Region, San Francisco, California, 32 pages.
- Weaver, W. and D. Hagans, 1996, *Sediment treatments and road restoration: protecting and restoring watersheds from sediment-related impacts*, In: Healing the Watershed, A Guide to the Restoration of Watersheds and Native Fish of the West (chapter 4), The Pacific Rivers Council, Eugene, Oregon, pages 109-139.

| Watershed Sensitivity Factors - Geomorphology | | |
|---|--------|----------|
| Geomorphology ¹ | Active | Inactive |
| Translational / Rotational Slide | 10 | 5 |
| Earthflow | 10 | 5 |
| Debris Slide | 10 | 5 |
| Debris Flow / Torrent | 10 | 5 |
| Debris Slide Amphitheater Slope | | 5 |
| Inner Gorge ² | | 5 |
| Disrupted Ground | | 7 |
| ¹ CDF/DMG Watershed Mapping Units | | |
| ² Inner gorge slopes identified by CDMG aerial photo interpretation as having formed by coalescing mass wasting scars; deem more susceptible to instability than inner gorge slopes classified only by steep slopes. | | |

| Watershed Sensitivity Factors - Geology | | |
|--|---|--------|
| Geology | Name | Factor |
| Tkfs | Franciscan Sed. | 4 |
| Tkfv | Franciscan Vol. | 2 |
| Tky, Ty | Yager fm. | 4 |
| Tp | Pullen fm. | 4 |
| Ter | Eel River fm. | 2 |
| Qtwu, Qtrd, Qtsb, Qc | Wildcat Group - Rio Dell, Scotia Bluffs, Carlotta | 3 |
| Qh | Hookton fm. | 4 |
| Qort, Qr, Qrt, Qf, Qal, Q | Miscellaneous Quaternary fms. | 2 |

| Watershed Sensitivity Factors - Slopes | |
|--|--------|
| Slope Gradient and or Slope Position | Factor |
| <35% | 1 |
| >35% to 50% | 4 |
| >50% to 65% | 7 |
| >65% | 9 |
| >50% to 65%, inner gorge ¹ | 10 |
| >65%, inner gorge ¹ | 12 |
| ¹ "Inner gorge" includes all slopes that lead uninterrupted, at a gradient of 50% or more, to a stream channel. | |

| Watershed Sensitivity Factors - Soils | | |
|--|--------------------|---------------------|
| Soils Number | Soil Name | Factor ¹ |
| 823, 823M | Atwell | 5 |
| 7118 | Boomer | 2 |
| 200 | Bottom Land | 1 |
| 877 | Cahto | 1 |
| 723 | Comptche | 2 |
| 100 | Farmland | 1 |
| 921 | Hely | 2 |
| 822 | Hoover | 2? |
| 812 | Hugo | 2 |
| 812M | Hugo Var. | 3 |
| 815 | Josephine | 3 |
| 855, 855V | Kinman | 5 |
| 835 | Kneeland | 3 |
| 835V | Kneeland Var. | 4 |
| 914 | Larabee | 3 |
| 914g | Larabee Gravel | 2 |
| 914v | Larabee Var. | 3 |
| 847 | Laughlin | 2 |
| Soils Number | Soil Name | Factor ¹ |
| 872 | Maymen | 1 |
| 839 | McMahon | 4 |
| 814, 814m | Melborne | 3 |
| 732 | Montara | 2 |
| 97x | No Name | 2? |
| 700 | No Soil | 1 |
| 813 | Orick | 3 |
| 934 | Rio Del | 3 |
| 820 | Sheet Iron | 2 |
| 748 | Sobrante | 2? |
| Strm | Stream | 0 |
| 819 | Tatu | 2 |
| 400 | Terraces | 1 |
| 922 | Tonini | 2 |
| 849 | Tyson | 2 |
| 81Y | Unnamed | 2? |
| 82X | Unnamed | 2? |
| 818 | Usal | 3 |
| 840 | Wilder | 1 |
| 752 | Yorkville | 5 |
| 852 | Zanone | 5 |
| 837, 842, 874, 918, ui | x1, x2, x3, x4, x7 | 2? |
| ¹ Soils with no information available ("2?") given an intermediate factor of 2. They are listed as "2?" | | |